JOURNAL OF INTERNATIONAL CRISIS AND RISK COMMUNICATION RESEARCH
ISSN: 2576-0017
2024, VOL 7, NO S5

Exploration of medical toxicology within the field of forensic medicine through a bibliometric study

León Arango Buelvas[1],José Marcelo Torres Ortega[2],William Niebles[3]

1.Universidad de Sucre,leon.arango@unisucre.edu.co
2.Universidad de Sucre
3.Universidad de Sucre

ABSTRACT
Conducted through a thorough review of the literature indexed in Scopus, the current study employs bibliometric analysis to ascertain the historical development and some critical aspects of research in medical toxicology and legal medicine from 2000 to 2024. This descriptive documentary approach allowed for the characterization of these fields of scientific production by way of identifying trends, leading authors, top countries and institutions, as well as growth in numbers of publications, document types, and patterns of collaboration in this area. The primary results showed 136 publications done from 589 authors, with an annual growth average of 7.36% in the last few years, being 2018, 2021, 2023, and 2024 the most productive years with 11 publications each one. FORENSIC SCIENCE INTERNATIONAL (with 8 publications) and JOURNAL OF FORENSIC SCIENCES (with 15 publications) were found to be the most productive sources leading in this field. India tops the list with 81 research papers, followed by the US at 62 and China coming in third with 37. VIVEKANANDA GLOBAL UNIVERSITY (14) and MAHIDOL UNIVERSITY (12) stand at the peak of institutions in contributing to the field of study. The authors who published the most contributions are NAGAR V, SHARMA S, and SUZUKI O. Lastly, among the most cited articles, the first was BOUMBA V in 2006, at INT J TOXICOL, with 161 citations overall, followed by MANI V, 2021, TRAC TRENDS ANAL CHEM, with 104 citations.
Key words: Medical toxicology, Toxic substances, Chemical substances, Legal medicine, Forensic sciences, Bibliometrics.

INTRODUCTION

As a multidisciplinary field of research, toxicology examines the harmful effects of chemicals on living things, such as people, animals, and the environment. This field is in charge of studying the mechanisms of action of certain chemicals, from exposure to clinical manifestation, in addition to detecting and measuring their detrimental effects (Avila et al., 2020). Among the several subfields of toxicology, medical toxicology—which focuses on how poisons affect human health and how to treat poisoning—stands apart. Its importance stems from its capacity to create treatment plans and public health regulations, as well as to stop diseases and fatalities brought on by exposure to harmful chemicals (Chary et al., 2020). Toxicology and legal medicine have a basic and significant interaction in this area. In order to resolve legal concerns, legal medicine, also known as forensic medicine, applies medical expertise and concepts to the legal system. By offering scientific proof about the presence of drugs in the human body, toxicology serves as a vital pillar in legal medicine (Sengupta, 2022). This proof may be used to confirm claims of purposeful or accidental poisoning, as well as to ascertain the cause of death and the level of intoxication in criminal cases.

Forensic toxicology is a vital tool for forensic physicians in the legal field. Toxins found in biological samples (such as blood, urine, hair, and tissues) might, for instance, indicate if a drug caused or contributed to a suspicious death. Toxicological testing is also used to assess a person's judgment at the time of a crime, which might influence guilt or the harshness of

punishments. This factor is especially important when it comes to assaults, traffic-related offenses, and child custody disputes involving drug misuse (Wille et al., 2021).

The investigation of workplace occurrences, where exposure to industrial or environmental toxins can be examined, and the testing of victims of sexual abuse to identify chemical submission medicines are more examples of how toxicology and forensic medicine intersect (De Souza et al., 2020). On the other side, toxicology provides data to demonstrate causal linkages between exposure and diseases or injuries, supporting litigation pertaining to culpability for damages caused by hazardous goods or drugs in the civil field (Roberts et al., 2022).

Medical toxicology and forensic medicine are closely related at the level of education and professional training. Toxicology modules are included into forensic medicine specializations and careers, and vice versa, preparing practitioners to handle situations holistically (Francese and King, 2024). This is seen in the scientific literature, where toxicologists and forensic physicians work together to produce research that advances both fields' understanding while also enhancing forensic procedures and justice (Shukla et al., 2024).

To put it briefly, toxicology provides objective, verifiable evidence that is crucial to the administration of justice in addition to informing about the risks posed by chemicals in a healthcare setting. In the sphere of health and law, the synergy between toxicological and legal medicine has developed into a crucial relationship that affects both poisoning prevention and case resolution, highlighting the significance of having a thorough and current grasp of both fields (Ojanperä, 2022).

Given this background, it is critical to conduct research that enables us to comprehend the ways in which toxicology and legal medicine interact in the realm of scientific literature, identifying important players, trends, and components that provide a springboard for further investigation and creativity. Researchers believe there are profound connections between the two professions. In order to investigate the current state of scientific knowledge on the relationships between toxicological and legal medicine, the current study is designed as a bibliometric review procedure (Donthu et al., 2021). This information from prestigious databases like Scopus enables high-impact research to disclose the current state of affairs on this subject.

MATERIALS AND METHODS

A quantitative methodology was used in this bibliometric analysis to examine the development and significance of research in forensic medicine and medical toxicology. The literature indexed in Scopus, a database renowned for its quality and coverage, was thoroughly and methodically reviewed (Kumar et al., 2023). The search, which was carried out in December 2024, concentrated on particular key terms associated with the research subjects. Advanced tools like R Studio and VOSviewer (Kemeç and Altınay, 2023) were utilized to examine bibliometric data, allowing for the visualization and study of scientific collaborative networks.

Characterizing scientific production in this area, including identifying trends, prominent authors, nations, and top institutions, was made possible by the descriptive documentary approach (Ramírez et al., 2024). Evaluations were conducted on indicators such collaboration patterns, document types, and publication growth rates (Mokhtari et al., 2020). Furthermore, the distribution of journal articles and author productivity were examined using traditional bibliometric laws like Bradford and Lotka, respectively (Gupta and Singh, 2023). In order to assess the influence and visibility of research in the fields of medical toxicology and legal medicine, a thorough examination of important indicators, including the importance of sources, institutional affiliations, and citation patterns, was conducted.

Table 1

Keywords standardization

Variable	Descriptor
Medical toxicology	"Toxic substances" "Chemical substances"
Medicine legal	"Forensic medicine" "Forensic sciences"

Source: Authors (2024).

TITLE-ABS-KEY ("medical toxicology") OR TITLE-ABS-KEY ("toxic substances") OR TITLE-ABS-KEY ("chemical substances") AND TITLE-ABS-KEY ("forensic medicine") OR TITLE-ABS-KEY ("forensic sciences") OR TITLE-ABS-KEY ("legal medicine") AND PUBYEAR > 1999 AND PUBYEAR < 2025 is the search equation that is suggested in the Scopus database based on the identification of these elements.

RESULTS

The analysis's first conclusion is that, out of 136 publications with 589 authors, the following table (Table 2) enables us to identify the general elements related to the scientific production of the knowledge area, where an annual growth of 7.36% has been observed in recent years.

Table 2

Main information of the data obtained from Scopus

MAIN INFORMATION ABOUT DATA	
Timespan	2000:2024
Sources (Journals, Books, etc)	88
Documents	136
Annual Growth Rate %	7.36
Document Average Age	9.81
Average citations per doc	14.08
References	4776
DOCUMENT CONTENTS	
Keywords Plus (ID)	1710
Author's Keywords (DE)	446
AUTHORS	
Authors	589
Authors of single-authored docs	13
AUTHORS COLLABORATION	
Single-authored docs	14
Co-Authors per Doc	4.57
International co-authorships %	11.03
DOCUMENT TYPES	
article	86
book chapter	8
conference paper	8
editorial	3
note	1
retracted	2
Review	30

Source: Authors (2024)

Similarly, figure 1 shows the increase in scientific output. Of these, 2018 was the most productive year, followed by 2021, 2023, and 2024, with an identical number of 11 papers,

followed by 2003, 2007 and 2019 with nine published papers. With just one document released, 2001 was the year with the least amount of production.

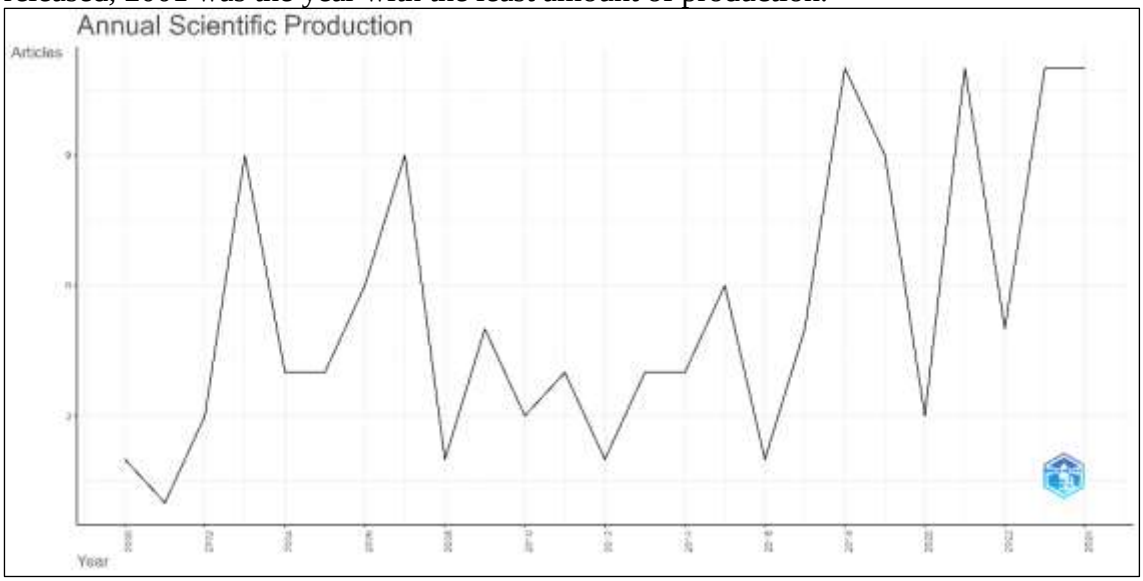

Figure 1. *Annual scientific production, Source: Authors (2024).*

Laws of bibliometric productivity

To better grasp the authors' influence on the field of knowledge, Lotka's law enables mapping the production curve on the N of authors (Borre et al., 2023). Table 3 demonstrates that 95% of the authors have provided just one document, 0.04% have contributed two, and 0.005% have contributed three or more.

Table 3

Lotka's Law

Documents written	N. of Authors	Proportion of Authors
1	560	0.951
2	26	0.044
3	3	0.005

Source: Authors (2024).

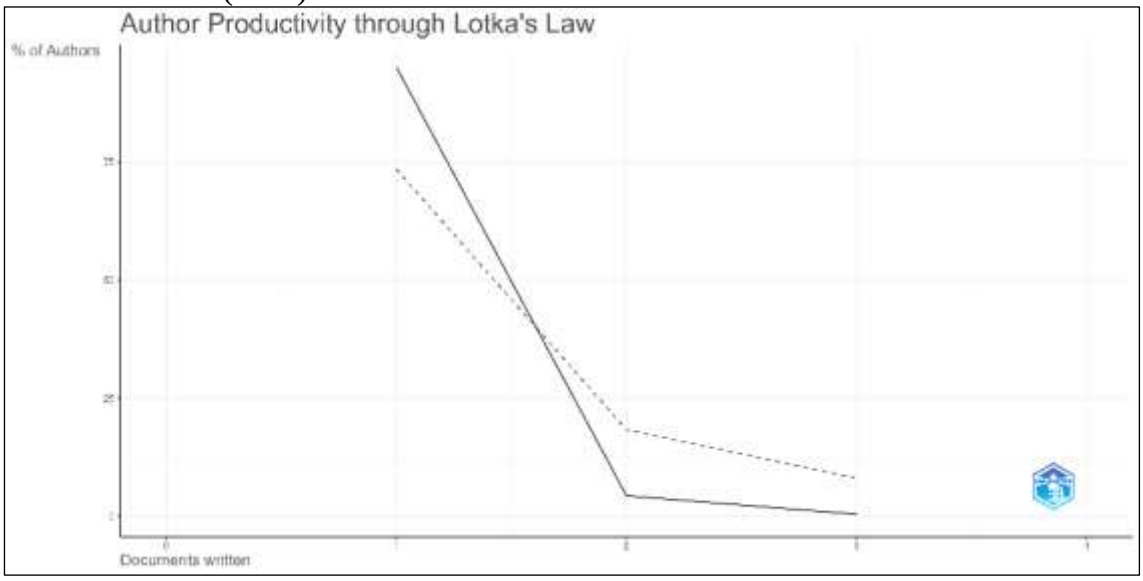

Figure 2. *Lotka's Law, Source: Authors (2024).*

According to the frequency of publications on the subject and the percentiles displayed by Bradford's law, which divides journals into three performance zones with an increase in the

number of journals and a comparable percentage of articles, the most pertinent sources are displayed (Ramírez et al., 2023). Each Bradford Law Zone's proportion is displayed in Table 4. Notably, zone 1 has a 33.19% participation rate with 68 magazines and 148 articles, which is somewhat comparable to zone 2's 33.86% rate; nevertheless, zone 1 has 151 publications and 151 articles of participation. In zone 3, there are 147 periodicals and 147 articles, and 32.95% of them are active.

Table 4

Bradford's Law

Zone	No. Magazines	No. Titles	Percentages
Zone 1	8	46	33.82%
Zone 2	36	46	33.82%
Zone 3	44	44	32.35%

Source: Authors (2024).

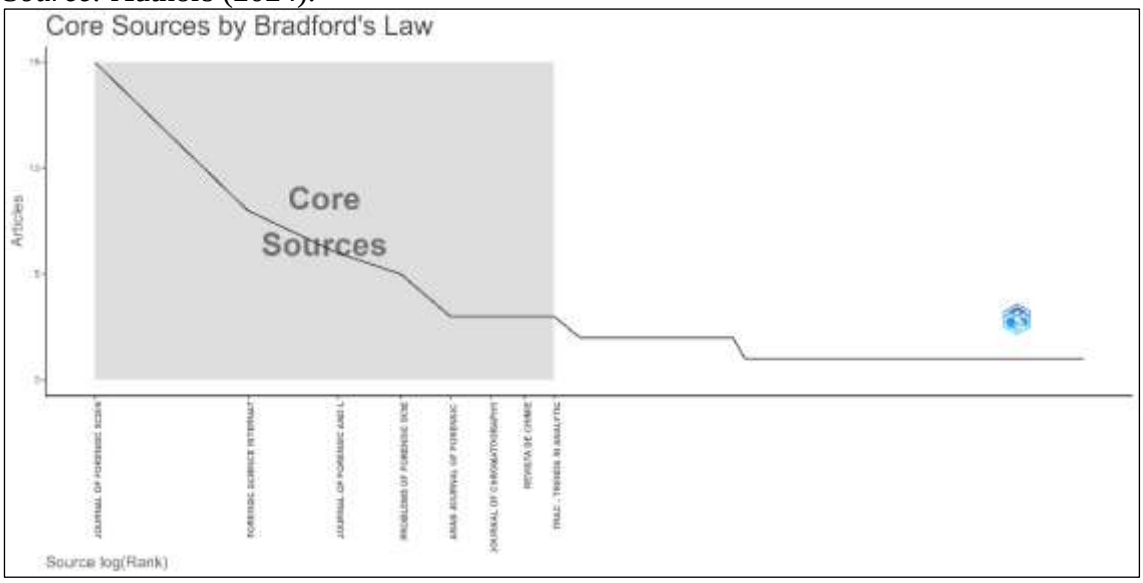

Figure 3. *Bradford's Law, Source: Authors (2024).*

Bibliometric indicators

With 15 articles, the Journal of Forensic Sciences leads the field, followed by the Journal of Forensic Science International with 8 publications and the Journal of Forensic and Legal Medicine with 6 publications, as seen in Table 5 (below).

The work of Chen et al. (2009) is one of the publications in the most referenced journal of all the ones the study discovered. The misuse of antibiotics in animal husbandry is still a worldwide issue, according to the researchers, and finding drug residues in complex biological matrices at low quantities presents significant analytical problems. In order to address this, our study created a useful biochip test technique to detect antibiotic residues in various animal tissue extracts. The antibody hapten chip technology demonstrated equivalent sensitivity and accuracy to a typical ultra-performance liquid chromatography-mass spectrometry (MS)/MS test, according to analytical data. The authors conclude that an efficient analytical detection method based on an antibody hapten chip was created in order to identify many antibiotic residues in a variety of samples.

Table 5
Most relevant sources

Sources	Articles
JOURNAL OF FORENSIC SCIENCES	15
FORENSIC SCIENCE INTERNATIONAL	8
JOURNAL OF FORENSIC AND LEGAL MEDICINE	6
PROBLEMS OF FORENSIC SCIENCES	5
ARAB JOURNAL OF FORENSIC SCIENCES AND FORENSIC MEDICINE	3
JOURNAL OF CHROMATOGRAPHY B: ANALYTICAL TECHNOLOGIES IN THE BIOMEDICAL AND LIFE SCIENCES	3
REVISTA DE CHIMIE	3
TRAC - TRENDS IN ANALYTICAL CHEMISTRY	3
AMERICAN JOURNAL OF FORENSIC MEDICINE AND PATHOLOGY	2
FORENSIC TOXICOLOGY	2

Source: Authors (2024).

A significant discrepancy in scientific output across the examined nations is shown in Figure 4. With 81 papers released, India is the clear leader, closely followed by China (37), and the United States (62). Although it is true that nations like Italy and Poland have comparable numbers, it is noteworthy how these three countries concentrate a sizable share of overall production, demonstrating their leadership position in research at a worldwide level.

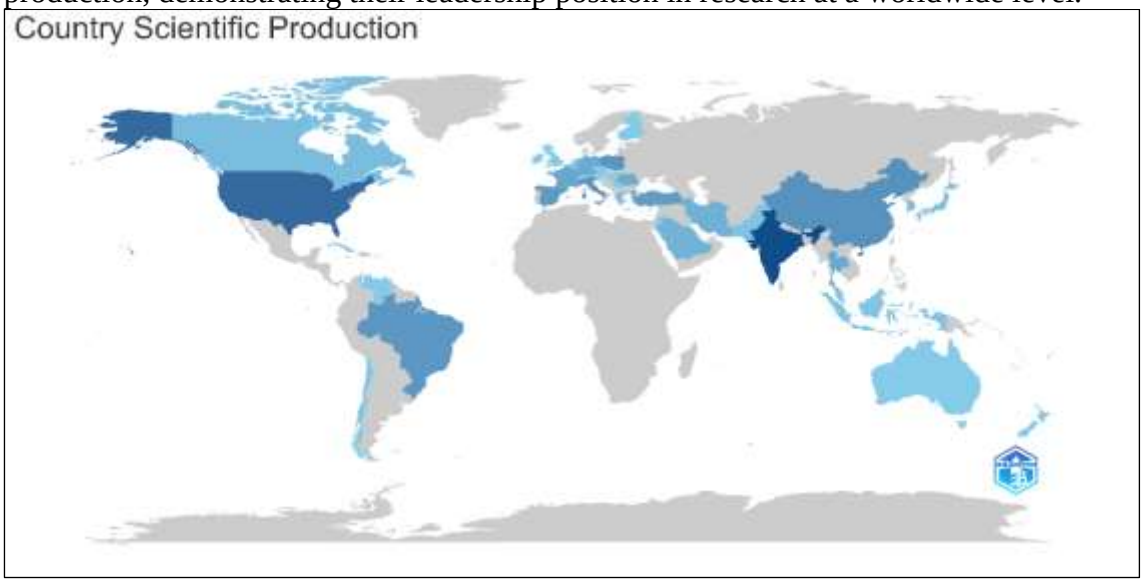

Figure 4. *Scientific Production By Country, Source: Authors (2024).*

The institutions that have contributed the most to the study topic are shown in figure 5 in this order of ideas: VIVEKANANDA GLOBAL UNIVERSITY (14) contributed, MAHIDOL UNIVERSITY (12) contributed, and UNIVERSITY OF MURCIA (13) contributed. Together, the three institutions have contributed 27.20% of the total articles.

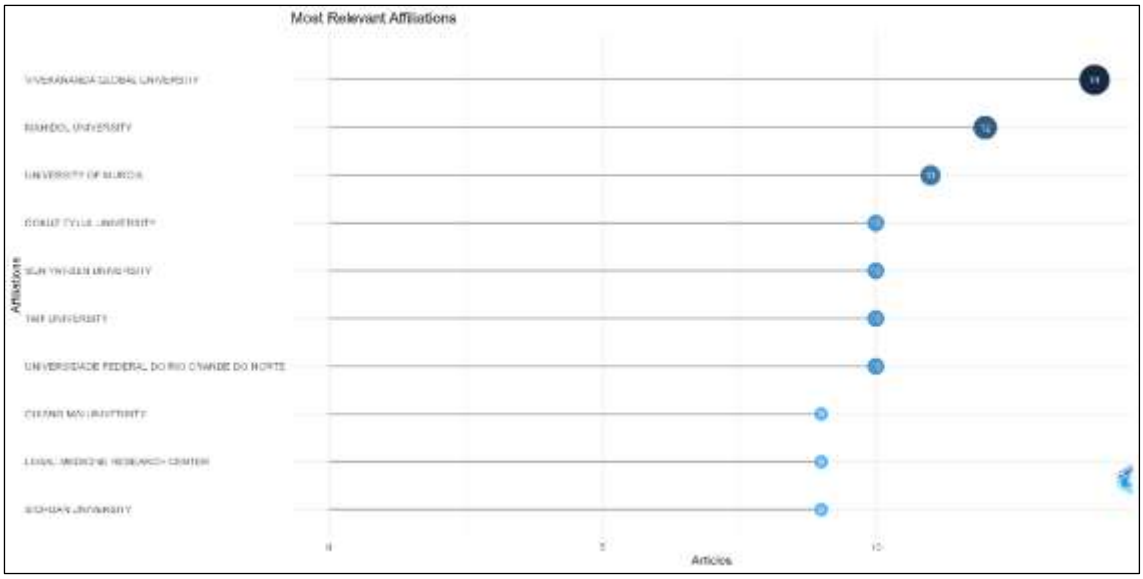

Figure 5. *Most Relevant Affiliations, Source: Authors (2024).*

Analyzing the researchers' individual production in Figure 6, it is evident that NAGAR V makes three (3) contributions, followed by SHARMA S and SUZUKI O, who both provide the same amount.

The analysis's most productive author is a co-author of an article published that same year (Krishna et al., 2024), in which the researchers explain that metal nanoparticles are important to the medical industry because of their desirable properties, including antimicrobial activity, anticancer properties, and their use in disease diagnosis. However, despite all of these benefits, metal nanoparticles are known to be toxic to living systems. Thus, a review of the five primary metal nanoparticles utilized in medicine—silver nanoparticles, gold, iron oxide, zinc oxide, and titanium dioxide—was conducted in the mentioned study. By presenting the toxicological consequences of these nanoparticles, biocompatibility, and the present and future clinical viewpoint of metal nanoparticles, this study adds to the issue covered in this bibliometric analysis.

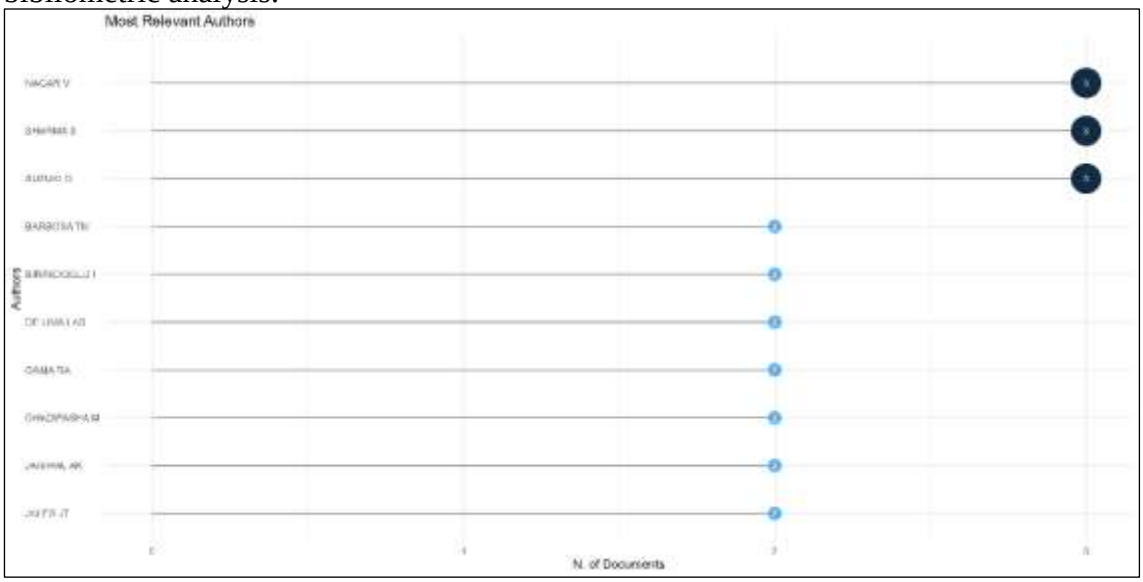

Figure 6. *Most Relevant Authors, Source: Authors (2024).*

Finally, table 6 lists the 25 articles that have the most citations on the subject of the study. The three most representative are BOUMBA V. (2006), INT J TOXICOL, with 161 citations overall; MANI V. (2021), TRAC TRENDS ANAL CHEM, in second place, with 104 citations; and KOWALSKI M. (2001), J PHYSIOL PHARMACOL, with 100 quotes.

According to the most referenced paper, which was created by Boumba et al. (2006), hair has emerged as a basic biological sample in recent years, serving as a substitute for the typical blood and urine samples used in drug testing in the domains of forensic toxicology, clinical toxicology, and chemistry. The referenced study then discusses methodological and practical concerns with the use of hair as a biological marker of drug use or misuse or chronic illnesses brought on by exposure to environmental pollutants. The entire process prompted researchers to examine the precise function of hair testing as well as the interpretation of hair analysis findings in light of the methods' limitations.

Table 6

Most cited articles

Articles	DOI	Total Citations	TC per Year	Normalized TC
BOUMBA V, 2006, INT J TOXICOL	10.1080/10915810600683028	161	8.47	3.51
MANI V, 2021, TRAC TRENDS ANAL CHEM	10.1016/j.trac.2020.116164	104	26.00	3.74
KOWALSKI M, 2001, J PHYSIOL PHARMACOL	URL: https://n9.cl/8qnfk	100	4.17	1.00
VALDEZ CA, 2018, REV ANAL CHEM	10.1515/revac-2017-0007	74	10.57	3.88
SAUVAGEAU A, 2006, J FORENSIC SCI	10.1111/j.1556-4029.2005.00032.x	74	3.89	1.61
CARDELL C, 2016, TRAC TRENDS ANAL CHEM	10.1016/j.trac.2015.12.001	71	7.89	1.97
GRUBER B, 2018, TRAC TRENDS ANAL CHEM	10.1016/j.trac.2018.05.017	66	9.43	3.46
LEESON A, 2021, ENVIRON TOXICOL CHEM	10.1002/etc.4894	59	14.75	2.12
CHARBONNET JA, 2021, ENVIRON SCI TECHNOL	10.1021/acs.est.0c08506	55	13.75	1.98
CAMPBELL GP, 2007, J FORENSIC SCI	10.1111/j.1556-4029.2007.00411.x	55	3.06	2.61
CHOPHI R, 2019, J FORENSIC LEG MED	10.1016/j.jflm.2019.07.010	48	8.00	2.90
KORDROSTAMI R, 2017, DARU J PHARM SCI	10.1186/s40199-017-0181-1	43	5.38	4.39
SOLTANINEJAD K, 2007, J FORENSIC LEG MED	10.1016/j.jflm.2006.12.011	41	2.28	1.94

LUZARDO OP, 2015, SCI JUSTICE	10.1016/j.scijus.2015.04.007	37	3.70	2.64
GARCÍA MG, 2021, J FORENSIC LEG MED	10.1016/j.jflm.2021.102151	34	8.50	1.22
SUKONTASON KL, 2008, PARASITOL RES	10.1007/s00436-008-1072-7	33	1.94	2.00
SUKONTASON KL, 2007, PARASITOL RES	10.1007/s00436-007-0660-2	32	1.78	1.52
MUSSHOFF F, 2006, AM J FORENSIC MED PATHOL	10.1097/01.paf.0000188167.70732.9d	31	1.63	0.68
ZHANG L, 2007, J SEP SCI	10.1002/jssc.200600363	31	1.72	1.47
ANGELINI DJ, 2019, FORENSIC SCI INT	10.1016/j.forsciint.2019.04.019	30	5.00	1.81
PASTOR-BELDA M, 2019, CHEM RES TOXICOL	10.1021/acs.chemrestox.9b00213	30	5.00	1.81
BELOW E, 2003, FORENSIC SCI INT	10.1016/S0379-0738(03)00058-6	29	1.32	2.39
ATHERTON D, 2019, J FORENSIC SCI	10.1111/1556-4029.13823	28	4.67	1.69
PAUK V, 2018, J CHROMATOGR B ANAL TECHNOL BIOMED LIFE SCI	10.1016/j.jchromb.2018.04.015	27	3.86	1.41
GARCÍA-CABALLERO C, 2014, REV ESP MED LEG	10.1016/j.reml.2013.07.003	25	2.27	2.27

Source: Authors (2024)

Analysis of relationships and co-occurrences

Finally, the term co-occurrence analysis, carried out with VOSviewer and presented in Figure 7, reveals that concepts such as "Human", "Toxic substance", "Forensic", "Science" and "Male" are central in the field of study.

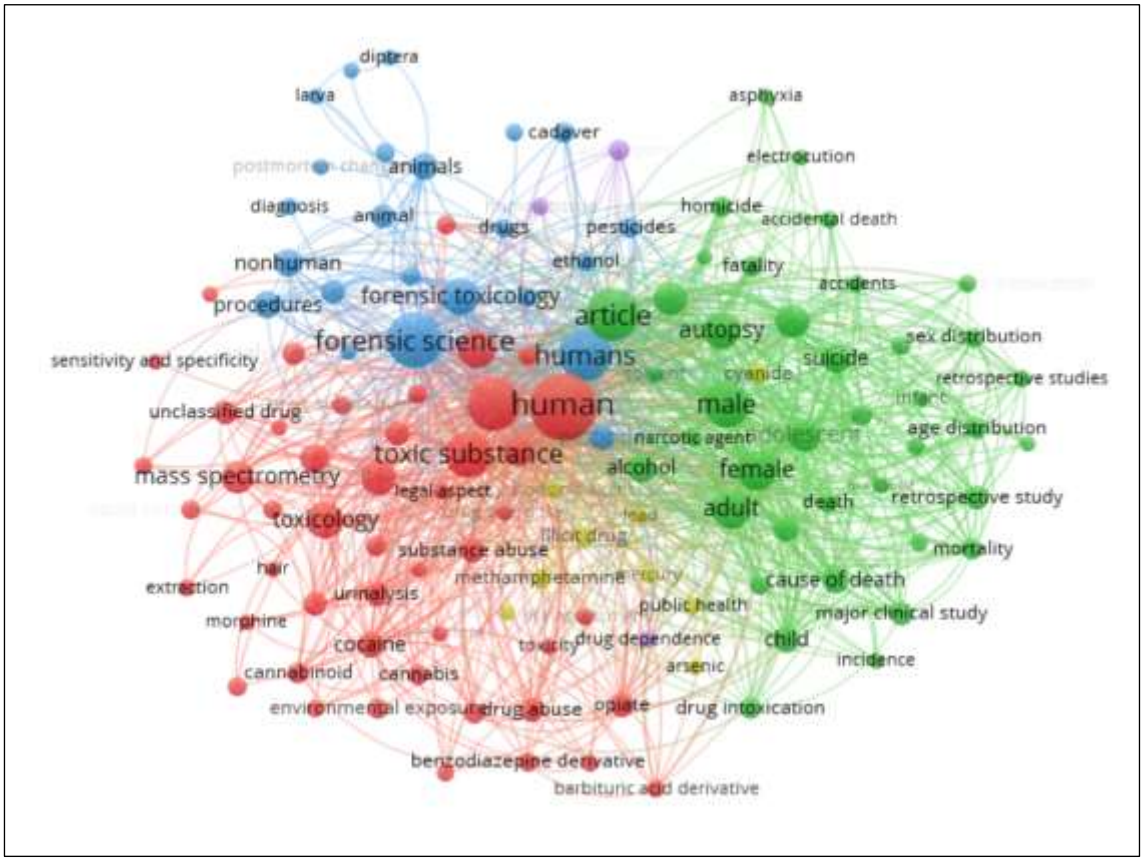

Figure 7. *Co-occurrence of Keywords, Source: Authors (2024).*

CONCLUSIONS

The markers of the growth of research in this field from 2000 to 2024 are emphasized following a thorough bibliometric analysis of toxicology in the context of legal medicine. By utilizing tools like R and VOSviewer to analyze data from Scopus, it was possible to identify patterns, editorial trends, and knowledge gaps that give a comprehensive picture of the topic's present state. These findings should be noted by researchers and organizations interested in comprehending and resolving issues linked to toxicology and forensic medicine.

The analysis revealed an average yearly growth in scientific productivity of 7.36%, with 136 documents published overall. This productivity level, which peaked in 2018, 2021, 2023, and 2024, suggests that interest in the subject is increasing. Nevertheless, the high average number of citations per document (14.08) indicates that this study may have a bigger influence. Lotka's law states that 95% of the authors only made one contribution, suggesting that the individual experts' study was inconsistent. Conversely, Bradford's rule allowed for the identification of the most significant journals, with zones 1 and 2 exhibiting a noteworthy performance, including around 67% of the pertinent articles dispersed among 151 journals.

Leading nations in scientific production include India, the United States and China, while organizations such as VIVEKANANDA GLOBAL UNIVERSITY, MAHIDOL UNIVERSITY and UNIVERSITY OF MURCIA made notable contributions. Nagar V is the most prolific author with three publications, indicating a moderate degree of expertise in the field. On the other hand, among the most cited publications that discuss toxicology and legal medicine, the work of BOUMBA V, 2006, INT J TOXICOL stood out, which reviewed methodological and practical issues related to the biological indicators of drug use/abuse or of chronic diseases resulting from exposure to environmental toxins.

Based on the aforementioned summary, this bibliometric analysis thoroughly summarizes the trends of toxicological research and its connections to legal medicine. Mapping what is already known and identifying regions that require more investigation are made easier by

locating publication patterns, well-known authors, and esteemed journals. In particular, research gaps in understudied areas may guide future efforts to provide workable solutions for resolving internal conflicts and fostering inclusive workplaces. Keywords like "Human," "Toxic substance," "Forensic," "Science," and "Male" currently stand out based on the co-occurrence analysis.

Given the significance of the issues facing the fields of toxicology and contemporary forensic medicine, it is advised to increase worldwide cooperation efforts and encourage multidisciplinary study. Supporting young researchers to make long-term contributions to this subject is also crucial for increasing the scope and impact of scientific production. This work may influence the investigation of novel medical and microbiological techniques associated with toxicology and forensic medicine in addition to generating scholarly contributions.

REFERENCES

Angelini, D. J., Biggs, T. D., Maughan, M. N., Feasel, M. G., Sisco, E., & Sekowski, J. W. (2019). Evaluation of a lateral flow immunoassay for the detection of the synthetic opioid fentanyl. *Forensic science international, 300*(1), 75-81. https://doi.org/10.1016/j.forsciint.2019.04.019

Atherton, D., Dye, D., Robinson, C. A., & Beck, R. (2019). n-Ethyl Pentylone-Related Deaths in Alabama. *Journal of forensic sciences, 64*(1), 304-308. https://doi.org/10.1111/1556-4029.13823

Avila, A. M., Bebenek, I., Bonzo, J. A., Bourcier, T., Bruno, K. L. D., Carlson, D. B., ... & Brown, P. C. (2020). An FDA/CDER perspective on nonclinical testing strategies: Classical toxicology approaches and new approach methodologies (NAMs). *Regulatory Toxicology and Pharmacology, 114*(1), 104662. https://doi.org/10.1016/j.yrtph.2020.104662

Below, E., & Lignitz, E. (2003). Cases of fatal poisoning in post-mortem examinations at the Institute of Forensic Medicine in Greifswald—analysis of five decades of post-mortems. *Forensic science international, 133*(1-2), 125-131. https://doi.org/10.1016/S0379-0738(03)00058-6

Borre, J. R., Romero, G. C., Gutiérrez, J. M., & Ramírez, J. (2023). Discussion of the aspects of the cultural and creative industries that impact on sustainable development: a systematic review. *Procedia Computer Science, 224*(1), 532-537. https://doi.org/10.1016/j.procs.2023.09.077

Boumba, V. A., Ziavrou, K. S., & Vougiouklakis, T. (2006). Hair as a biological indicator of drug use, drug abuse or chronic exposure to environmental toxicants. *International Journal of Toxicology, 25*(3), 143-163. https://doi.org/10.1080/10915810600683028

Campbell, G. P., & Gordon, A. L. (2007). Analysis of condom lubricants for forensic casework. *Journal of forensic sciences, 52*(3), 630-642. https://doi.org/10.1111/j.1556-4029.2007.00411.x

Cardell, C., & Guerra, I. (2016). An overview of emerging hyphenated SEM-EDX and Raman spectroscopy systems: Applications in life, environmental and materials sciences. *TrAC Trends in Analytical Chemistry, 77*(1), 156-166. https://doi.org/10.1016/j.trac.2015.12.001

Charbonnet, J. A., Rodowa, A. E., Joseph, N. T., Guelfo, J. L., Field, J. A., Jones, G. D., ... & Houtz, E. F. (2021). Environmental source tracking of per-and polyfluoroalkyl substances within a forensic context: current and future techniques. *Environmental science & technology, 55*(11), 7237-7245. https://doi.org/10.1021/acs.est.0c08506

Chary, M. A., Manini, A. F., Boyer, E. W., & Burns, M. (2020). The role and promise of artificial intelligence in medical toxicology. *Journal of Medical Toxicology, 16*(4), 458-464. https://doi.org/10.1007/s13181-020-00769-5

Chen, A., Wang, G., Cao, Q., Wang, Y., Zhang, Z., Sun, Y., ... & Cheng, J. (2009). Development of an antibody hapten-chip system for detecting the residues of multiple antibiotic drugs. *Journal of forensic sciences, 54*(4), 953-960. https://doi.org/10.1111/j.1556-4029.2009.01049.x

Chophi, R., Sharma, S., Sharma, S., & Singh, R. (2019). Forensic entomotoxicology: current concepts, trends and challenges. *Journal of forensic and legal medicine, 67*(1), 28-36. https://doi.org/10.1016/j.jflm.2019.07.010

De Souza Costa, Y. R., Lavorato, S. N., & de Campos, J. J. C. M. (2020). Violence against women and drug-facilitated sexual assault (DFSA): a review of the main drugs. *Journal of forensic and legal medicine, 74*(1), 102020. https://doi.org/10.1016/j.jflm.2020.102020

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research, 133*(1), 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

Francese, S., & King, R. S. (Eds.). (2024). *Driving Forensic Innovation in the 21st Century: Crossing the Valley of Death*. Springer Nature. https://n9.cl/o0qqy

García, M. G., Pérez-Cárceles, M. D., Osuna, E., & Legaz, I. (2021). Drug-facilitated sexual assault and other crimes: A systematic review by countries. *Journal of forensic and legal medicine, 79*(1), 102151. https://doi.org/10.1016/j.jflm.2021.102151

García-Caballero, C., Cruz-Landeira, A., & Quintela-Jorge, Ó. (2014). Sumisión química en casos de presuntos delitos contra la libertad sexual analizados en el Instituto Nacional de Toxicología y Ciencias Forenses (Departamento de Madrid) durante los años 2010, 2011 y 2012. *Revista Española de Medicina Legal, 40*(1), 11-18. https://doi.org/10.1016/j.reml.2013.07.003

Gruber, B., Weggler, B. A., Jaramillo, R., Murrell, K. A., Piotrowski, P. K., & Dorman, F. L. (2018). Comprehensive two-dimensional gas chromatography in forensic science: A critical review of recent trends. *TrAC Trends in Analytical Chemistry, 105*(1), 292-301. https://doi.org/10.1016/j.trac.2018.05.017

Gupta, S., & Singh, V. K. (2023). Quantitative estimation of trends in artificial intelligence research: a study of Bradford distributions using leimkuhler model. *Journal of Scientometric Research, 12*(2), 234-242. https://dx.doi.org/10.5530/jscires.12.2.023

Kemeç, A., & Altınay, A. T. (2023). Sustainable energy research trend: A bibliometric analysis using VOSviewer, RStudio bibliometrix, and CiteSpace software tools. *Sustainability, 15*(4), 3618. https://doi.org/10.3390/su15043618

Kordrostami, R., Akhgari, M., Ameri, M., Ghadipasha, M., & Aghakhani, K. (2017). Forensic toxicology analysis of self-poisoning suicidal deaths in Tehran, Iran; trends between 2011-2015. *DARU Journal of Pharmaceutical Sciences, 25*(1), 1-10. https://doi.org/10.1186/s40199-017-0181-1

Kowalski, M. (2001). Helicobacter pylori (H. pylori) infection in coronary artery disease: influence of H. pylori eradication on coronary artery lumen after percutaneous transluminal coronary angioplasty. The detection of H. pylori specific DNA in human coronary atherosclerotic plaque. *Journal of physiology and pharmacology: an official journal of the Polish Physiological Society, 52*(1 Suppl 1), 3-31. https://n9.cl/8qnfk

Krishna, R., Nagar, V., Kaur, A., Rai, A. R., Awasthi, K. K., Awasthi, G., & Sankhla, M. S. (2024, February). Toxicological Effects of Metal Nanoparticles Employed in

Biomedicine: Biocompatibility, Clinical Trials, and Future Perspective. In *Macromolecular Symposia* (Vol. 413, No. 1, p. 2300057). https://doi.org/10.1002/masy.202300057

Kumar, M., George, R. J., & PS, A. (2023). Bibliometric analysis for medical research. *Indian Journal of Psychological Medicine*, *45*(3), 277-282. https://doi.org/10.1177/02537176221103617

Leeson, A., Thompson, T., Stroo, H. F., Anderson, R. H., Speicher, J., Mills, M. A., ... & Patton, C. (2021). Identifying and managing aqueous film-forming foam-derived per-and polyfluoroalkyl substances in the environment. *Environmental Toxicology and Chemistry*, *40*(1), 24-36. https://doi.org/10.1002/etc.4894

Luzardo, O. P., Almeida-González, M., Ruiz-Suárez, N., Zumbado, M., Henríquez-Hernández, L. A., Meilán, M. J., ... & Boada, L. D. (2015). Validated analytical methodology for the simultaneous determination of a wide range of pesticides in human blood using GC–MS/MS and LC–ESI/MS/MS and its application in two poisoning cases. *Science & Justice*, *55*(5), 307-315. https://doi.org/10.1016/j.scijus.2015.04.007

Mani, V., Beduk, T., Khushaim, W., Ceylan, A. E., Timur, S., Wolfbeis, O. S., & Salama, K. N. (2021). Electrochemical sensors targeting salivary biomarkers: A comprehensive review. *TrAC Trends in Analytical Chemistry*, *135*(1), 116164. https://doi.org/10.1016/j.trac.2020.116164

Mokhtari, H., Barkhan, S., Haseli, D., & Saberi, M. K. (2020). A bibliometric analysis and visualization of the Journal of Documentation: 1945–2018. *Journal of documentation*, *77*(1), 69-92. https://doi.org/10.1108/JD-08-2019-0165

Musshoff, F., Padosch, S. A., Kroener, L. A., & Madea, B. (2006). Accidental autoerotic death by volatile substance abuse or nonsexually motivated accidents?. The American journal of forensic medicine and pathology, 27(2), 188-192. https://doi.org/10.1097/01.paf.0000188167.70732.9d

Ojanperä, I. (2022). Legal Aspects of Toxicology. *Handbook of Forensic Medicine*, *2*(1), 1077-1098. https://doi.org/10.1002/9781119648628.ch46

Pastor-Belda, M., Campillo, N., Arroyo-Manzanares, N., Torres, C., Pérez-Cárceles, M. D., Hernández-Córdoba, M., & Viñas, P. (2019). Bioaccumulation of polycyclic aromatic hydrocarbons for forensic assessment using gas chromatography–mass spectrometry. *Chemical Research in Toxicology*, *32*(8), 1680-1688. https://doi.org/10.1021/acs.chemrestox.9b00213

Pauk, V., & Lemr, K. (2018). Forensic applications of supercritical fluid chromatography–mass spectrometry. *Journal of Chromatography B*, *1086*(1), 184-196. https://doi.org/10.1016/j.jchromb.2018.04.015

Ramirez, J., Gallego, G., Ez, W. N. N. N., & Tirado, J. G. (2023). Blockchain technology for sustainable supply chains: A bibliometric study. *Journal of Distribution Science*, *21*(6), 119-129. https://doi.org/10.15722/jds.21.06.202306.119

Ramirez, J., Herrera, H., Redondo, O., & Sulbaran, S. (2024). Implementation of Artificial Intelligence Systems for Agri-food Supply Chains: A Bibliometric Approach. Journal of Distribution Science, 22(6), 83-93. https://doi.org/10.15722/jds.22.06.202406.83

Roberts, S. M., James, R. C., & Williams, P. L. (Eds.). (2022). *Principles of toxicology: environmental and industrial applications*. John Wiley & Sons. https://n9.cl/9omr1

Sauvageau, A., & Racette, S. (2006). Autoerotic deaths in the literature from 1954 to 2004: a review. *Journal of Forensic Sciences*, *51*(1), 140-146. https://doi.org/10.1111/j.1556-4029.2005.00032.x

Sengupta, P., Chatterjee, B., & Tekade, R. K. (2022). Drug toxicity and forensic pharmacokinetics. In *Pharmacokinetics and Toxicokinetic Considerations* (pp. 425-486). Academic Press. https://doi.org/10.1016/B978-0-323-98367-9.00021-4

Shukla, S., Khanna, S., Dalal, J., Sankhyan, D., & Khanna, K. (2024). Emerging global trends and development in forensic toxicology: A review. *Journal of forensic and legal medicine*, *103*(1), 102675. https://doi.org/10.1016/j.jflm.2024.102675

Soltaninejad, K., Faryadi, M., & Sardari, F. (2007). Acute pesticide poisoning related deaths in Tehran during the period 2003–2004. *Journal of forensic and legal medicine, 14*(6), 352-354. https://doi.org/10.1016/j.jflm.2006.12.011

Sukontason, K. L., Ngern-Klun, R., Sripakdee, D., & Sukontason, K. (2007). Identifying fly puparia by clearing technique: application to forensic entomology. *Parasitology Research, 101*(1), 1407-1416. https://doi.org/10.1007/s00436-007-0660-2

Sukontason, K. L., Sribanditmongkol, P., Chaiwong, T., Vogtsberger, R. C., Piangjai, S., & Sukontason, K. (2008). Morphology of immature stages of Hemipyrellia ligurriens (Wiedemann)(Diptera: Calliphoridae) for use in forensic entomology applications. *Parasitology research*, *103*(1), 877-887. https://doi.org/10.1007/s00436-008-1072-7

Valdez, C. A., Leif, R. N., Hok, S., & Hart, B. R. (2018). Analysis of chemical warfare agents by gas chromatography-mass spectrometry: methods for their direct detection and derivatization approaches for the analysis of their degradation products. *Reviews in Analytical Chemistry, 37*(1), 20170007. https://doi.org/10.1515/revac-2017-0007

Wille, S. M., Van Dijck, K., Van Assche, A., Di Fazio, V., Ramiréz-Fernandéz, M. D. M., Vanvooren, V., & Samyn, N. (2021). The interest of a systematic toxicological analysis combined with forensic advice to improve the judicial investigation and final judgment in drug facilitated sexual assault cases. *Pharmaceuticals, 14*(5), 432. https://doi.org/10.3390/ph14050432

Zhang, L., Wang, R., Zhang, Y., & Yu, Y. (2007). Application of high performance capillary electrophoresis on toxic alkaloids analysis. *Journal of separation science, 30*(9), 1357-1363. https://doi.org/10.1002/jssc.200600363